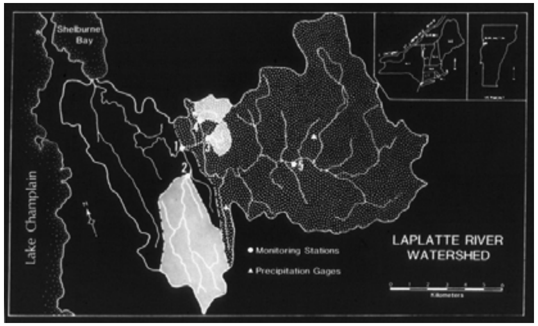
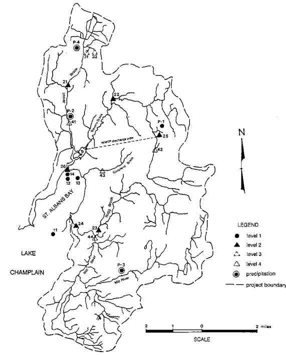
Lag time in water quality response to land treatment

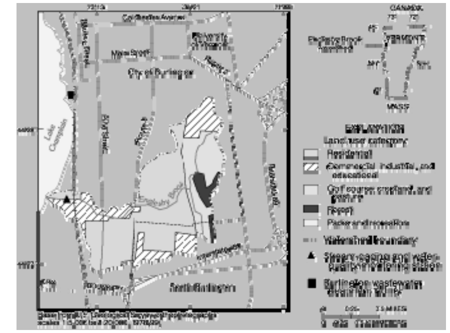


Donald W. Meals
Steven A. Dressing

TETRA TECH, INC.





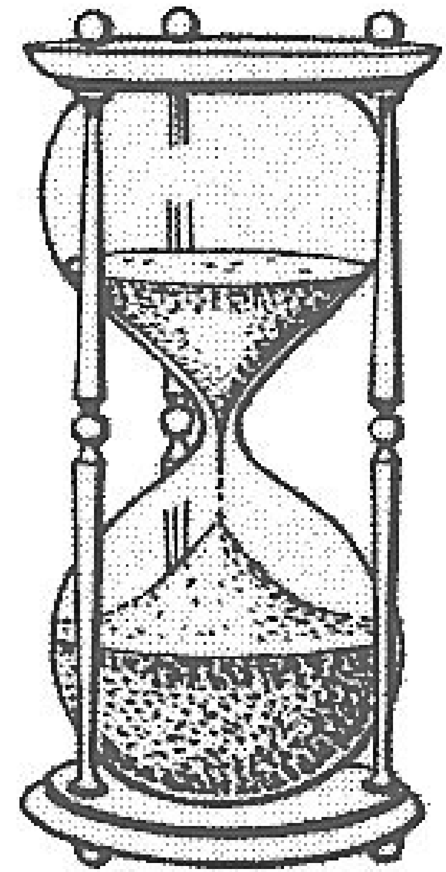


Some watershed land treatment projects have reported little or no improvement in water quality after extensive implementation of best management practices (BMPs) in the watershed:

- **insufficient landowner participation**
- **uncooperative weather**
- **improper selection of BMPs**
- **mistakes in understanding of pollution sources**
- **poor experimental design**
- **inadequate level of treatment**

Lag time

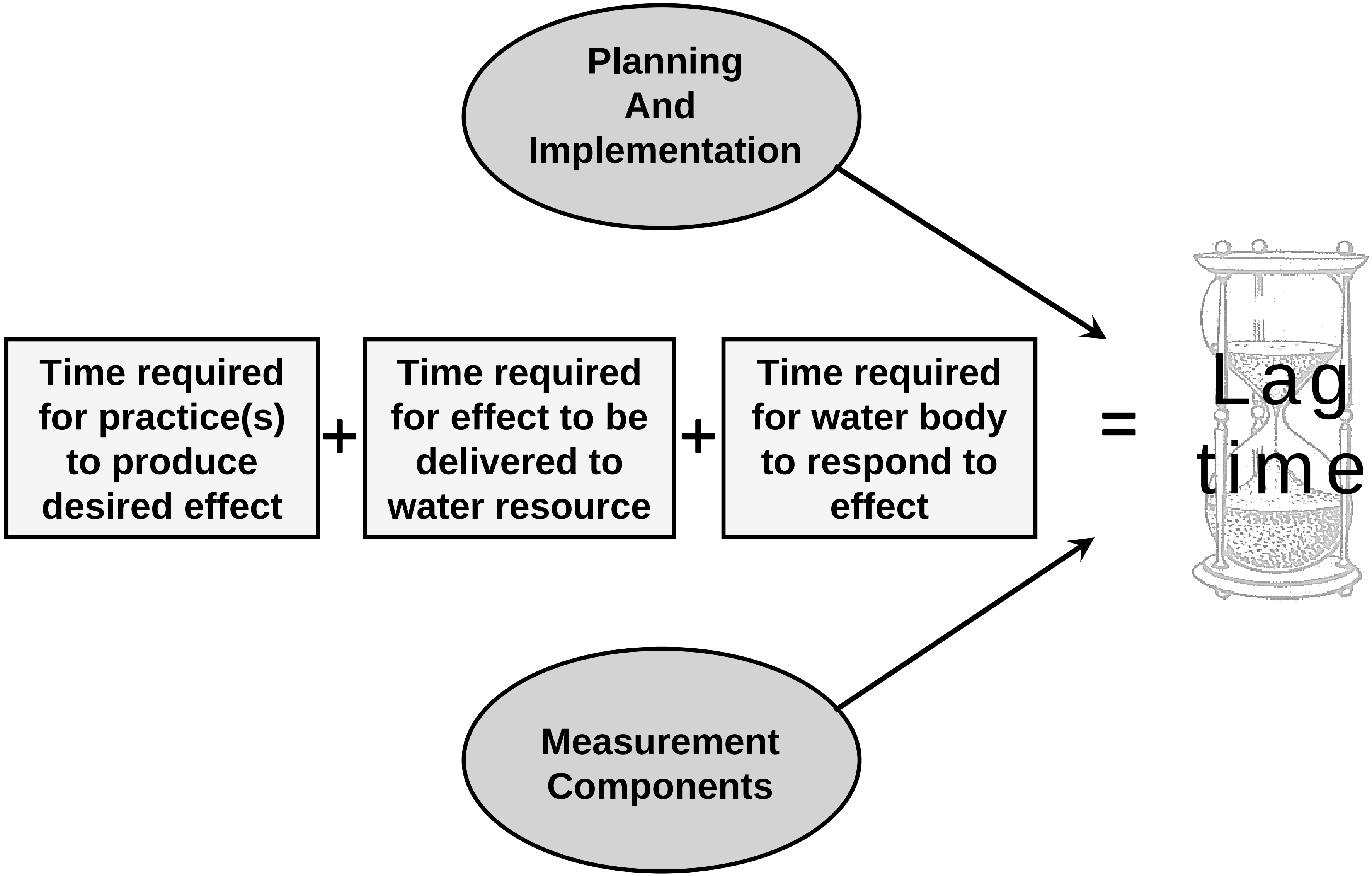
An inherent characteristic of natural systems generally defined as the amount of time between an action and the response to that action



Lag time is the time elapsed between installation or adoption of land treatment and measurable improvement of water quality.

If lag time > monitoring period…..

May not show definitive water quality results


Planning
And
Implementation
Time required
for practice(s)
to produce
desired effect
+
Time required
for effect to be
delivered to
water resource
+
Time required
for water body
to respond to
effect
=
Lag
time
Measurement
Components

Planning & Implementation

- **identify pollution sources and critical areas**
- **engage landowner participation**
- **design and install management measures**
- **integrate new practices into cropping and land management cycles.**

Stakeholders – especially the general public – will experience the planning and implementation process as part of the wait for results.

Time Required for Practice to Produce Effect

BMP Development

Time Required for Practice to Produce Effect

BMP Development

- [TP] -15%
- [TKN] -12%
- [TSS] -34%
- *E. coli* -29%

Time Required for Practice to Produce Effect

BMP Development

Time Required for Practice to Produce Effect

BMP Development

?

Time Required for Practice to Produce Effect

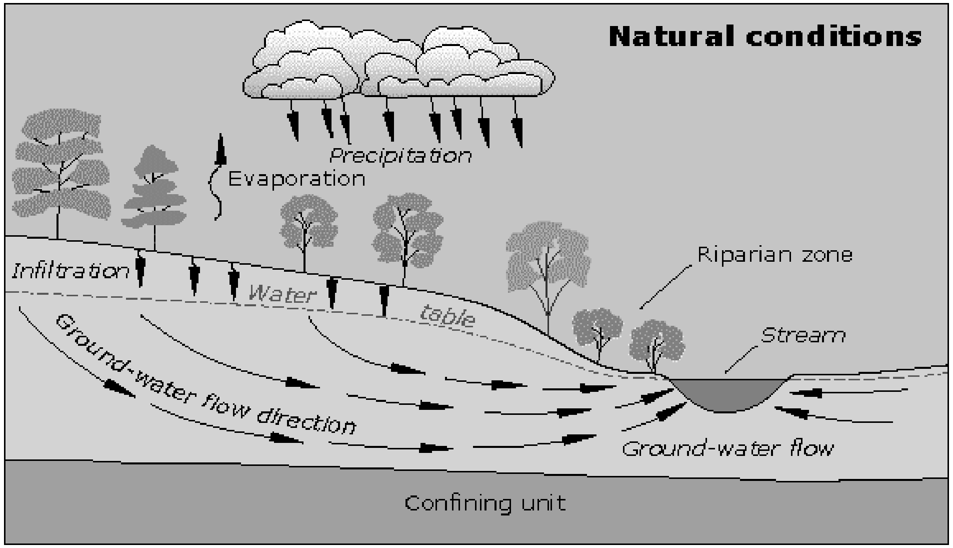
Source Behavior

Time Required for Practice to Produce Effect

Source Behavior

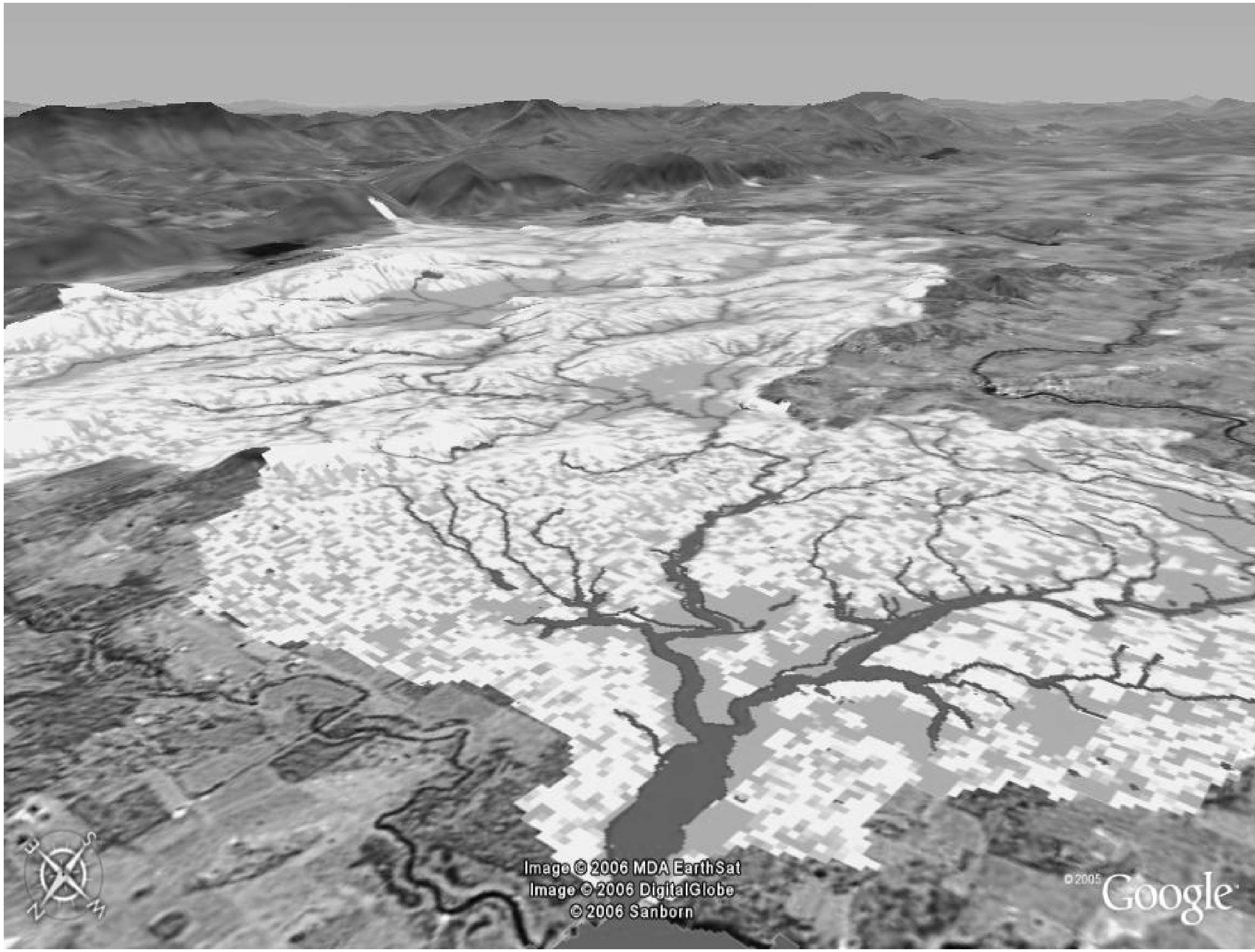
Time Required for Effect to be Delivered

- **Delivery route**
  - Direct or adjacent
  - Overland flow
  - Ground water



Time Required for Effect to be Delivered

- **Path distance**



Time Required for Effect to be Delivered

- **Path travel rate**
  - Fast (ditches, tile outlets)
  - Moderate (overland./subsurface flow in porous soils
  - Slow (groundwater infiltration w/o macropores)
  - Very slow (regional aquifer)

Time Required for Effect to be Delivered

- **Precipitation patterns**

Time Required for Effect to be Delivered

- **Nature of pollutant**

Dissolved

Time Required for Effect to be Delivered

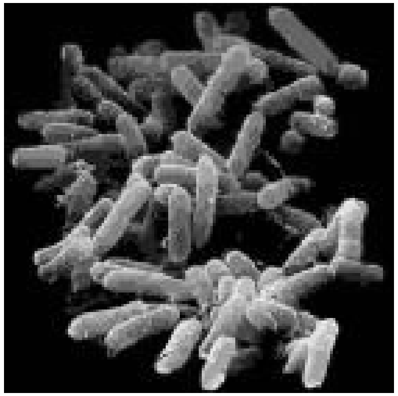
- **Nature of pollutant**

Particulate

Time Required for Water Body to Respond

- **Nature of indicator/impairment**

Indicator bacteria
- Die-off from environmental stresses
- Even with survival in aquatic sediments, stock eventually depleted



Synthetic organics
- Persistence
- Bioaccumulation

Time Required for Water Body to Respond

- **Nature of indicator/impairment**

Habitat

Time Required for Water Body to Respond

- **Nature of indicator/impairment**

Habitat

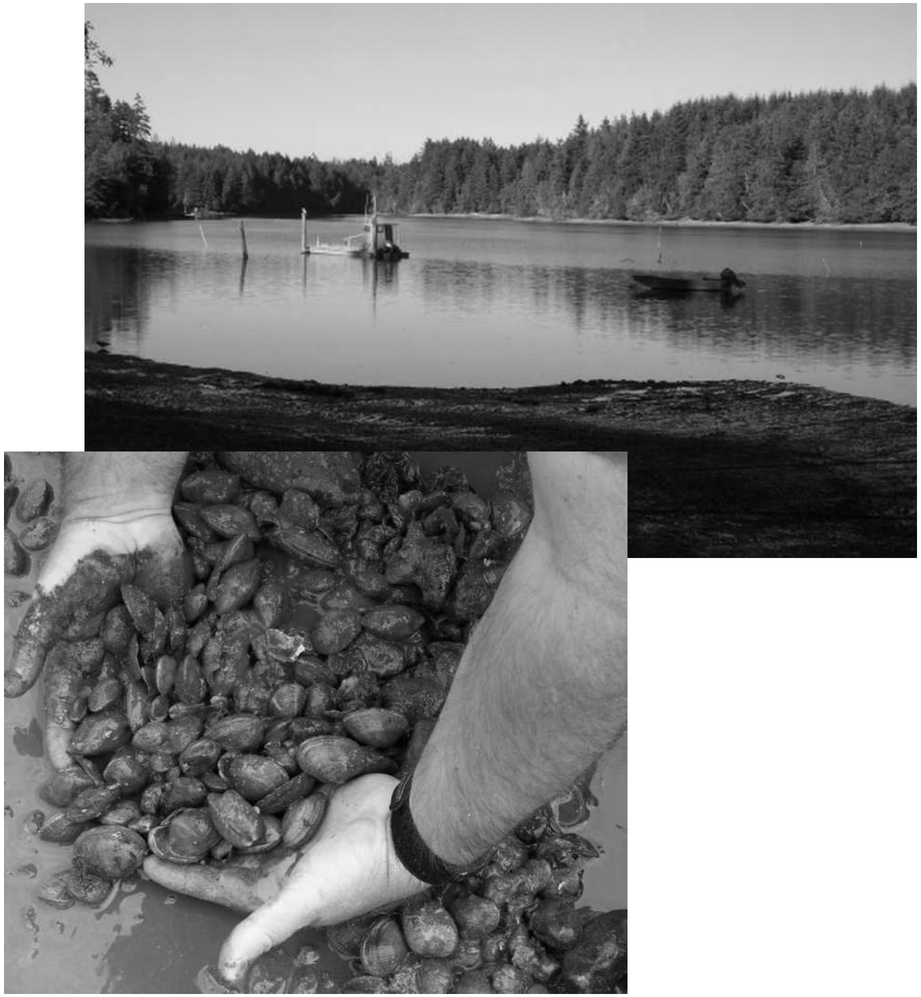
Biota

Time Required for Water Body to Respond

- **Receiving water response**

Bacteria from animal waste

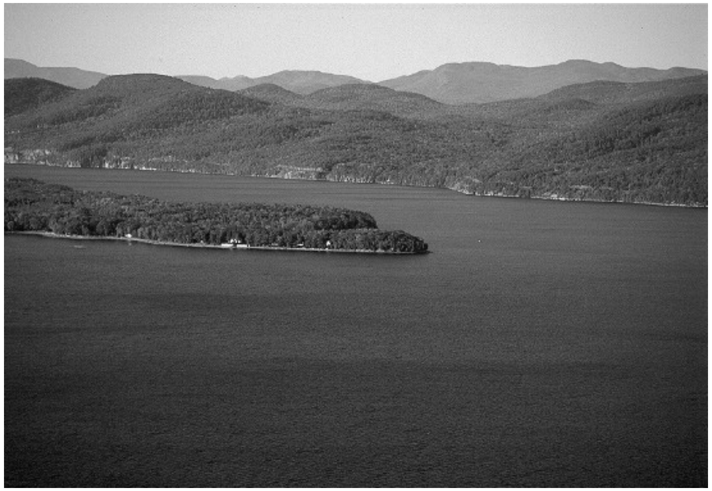
Shellfish beds



Time Required for Water Body to Respond

- **Receiving water response**

Transparency?
Algae blooms?



P in aquatic sediments

Measurement Components

Design of the monitoring program is a major determinant of ability to discern a response against the background of the variability of natural systems

Sampling frequency

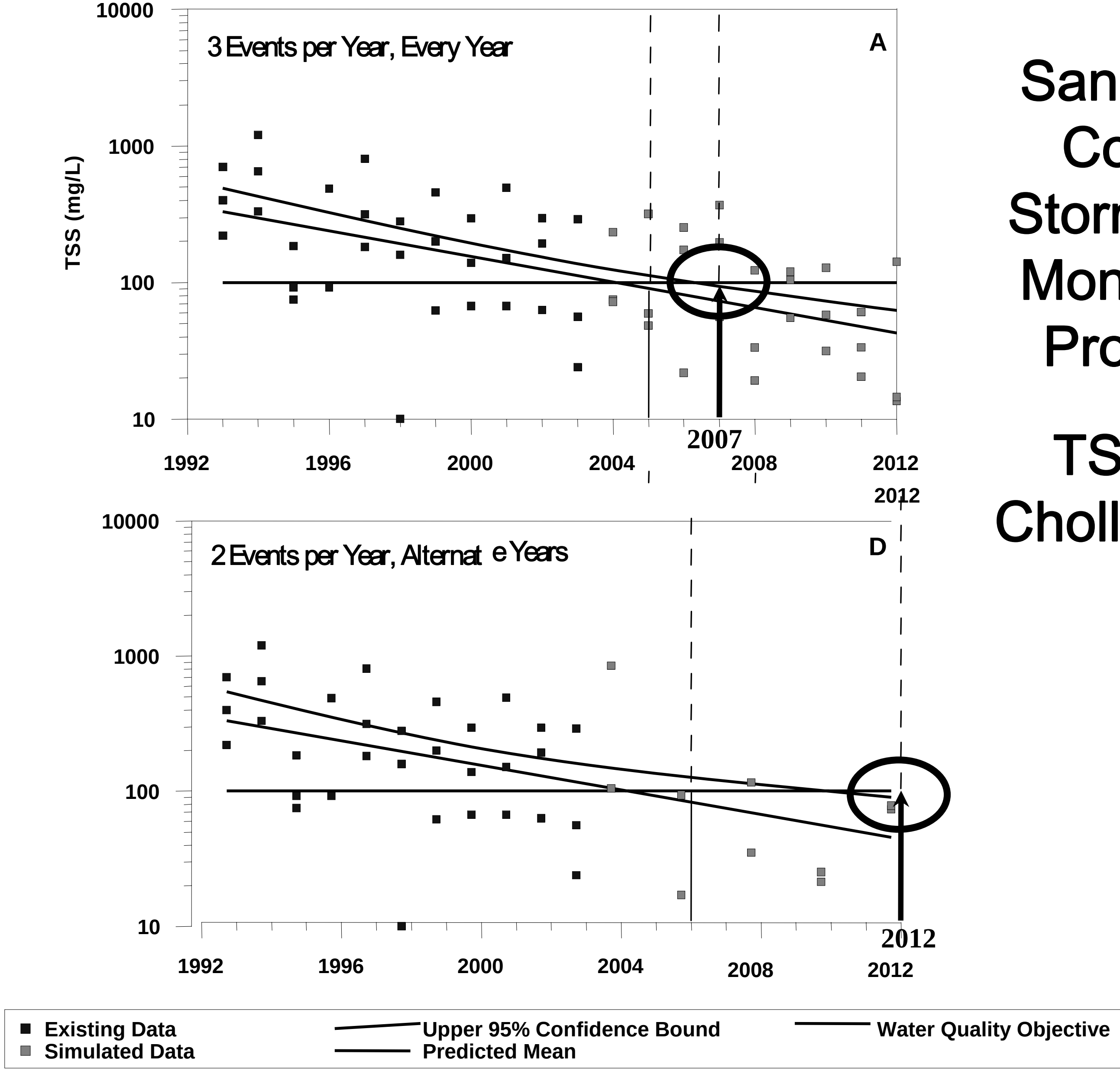
Taking fewer samples a year introduces an additional “statistical” lag time before a change can be effectively documented.

Minimum detectable change = how much change must occur (e.g., from implementation of conservation practices) for the change to be statistically significant.

The minimum detectable change (MDC) is given by

$$MDC = T_{(n_{pre}+n_{post}-k-2)}\sqrt{\frac{MSE_{pre}}{n_{pre}}+\frac{MSE_{post}}{n_{post}}} \quad (1a)$$

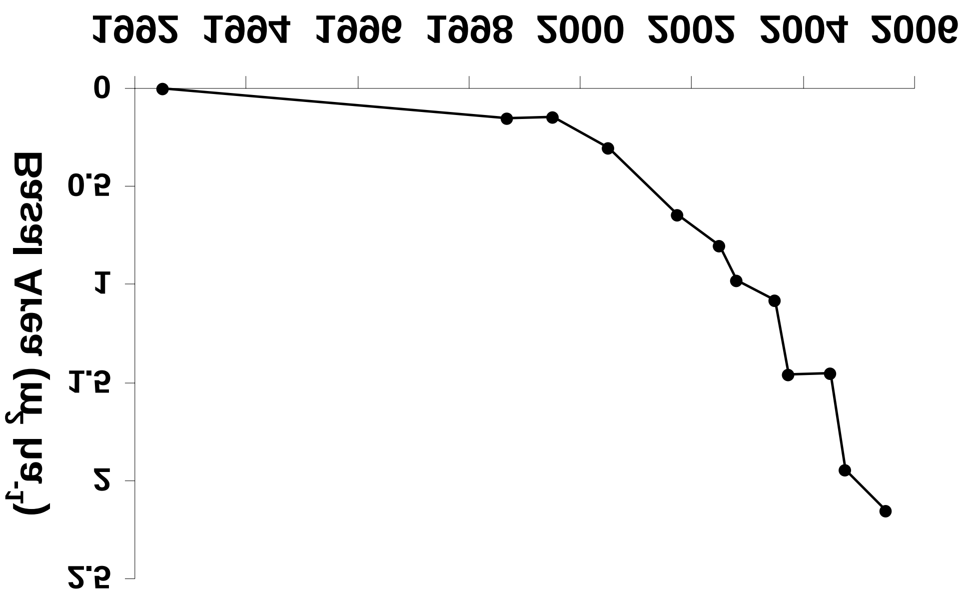
Richards and Grabow, 2003. Detecting Reductions in Sediment Loads Associated With Ohio's Conservation Reserve Enhancement Program. J. American Water Resour. Assoc. 39(5):1261-1268.



San Diego County Stormwater Monitoring Program

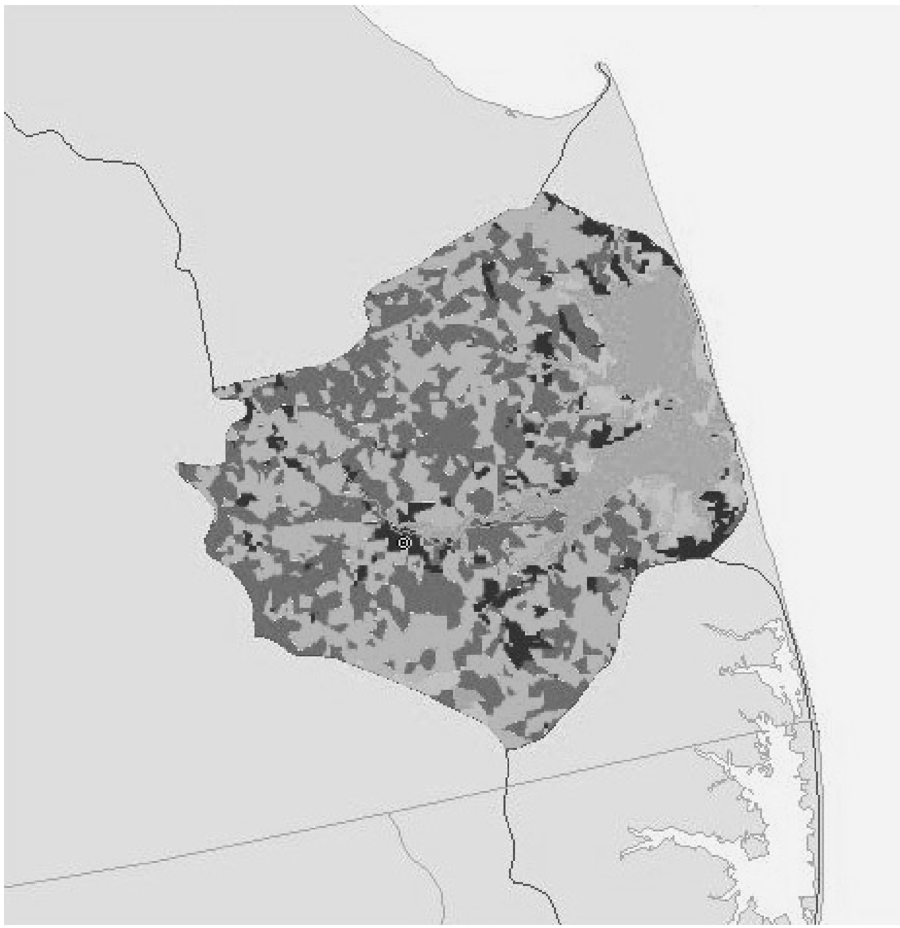
TSS data Chollas Creek

Magnitude of lag time



PA –
8 to 12 years to grow riparian forest buffer

Magnitude of lag time



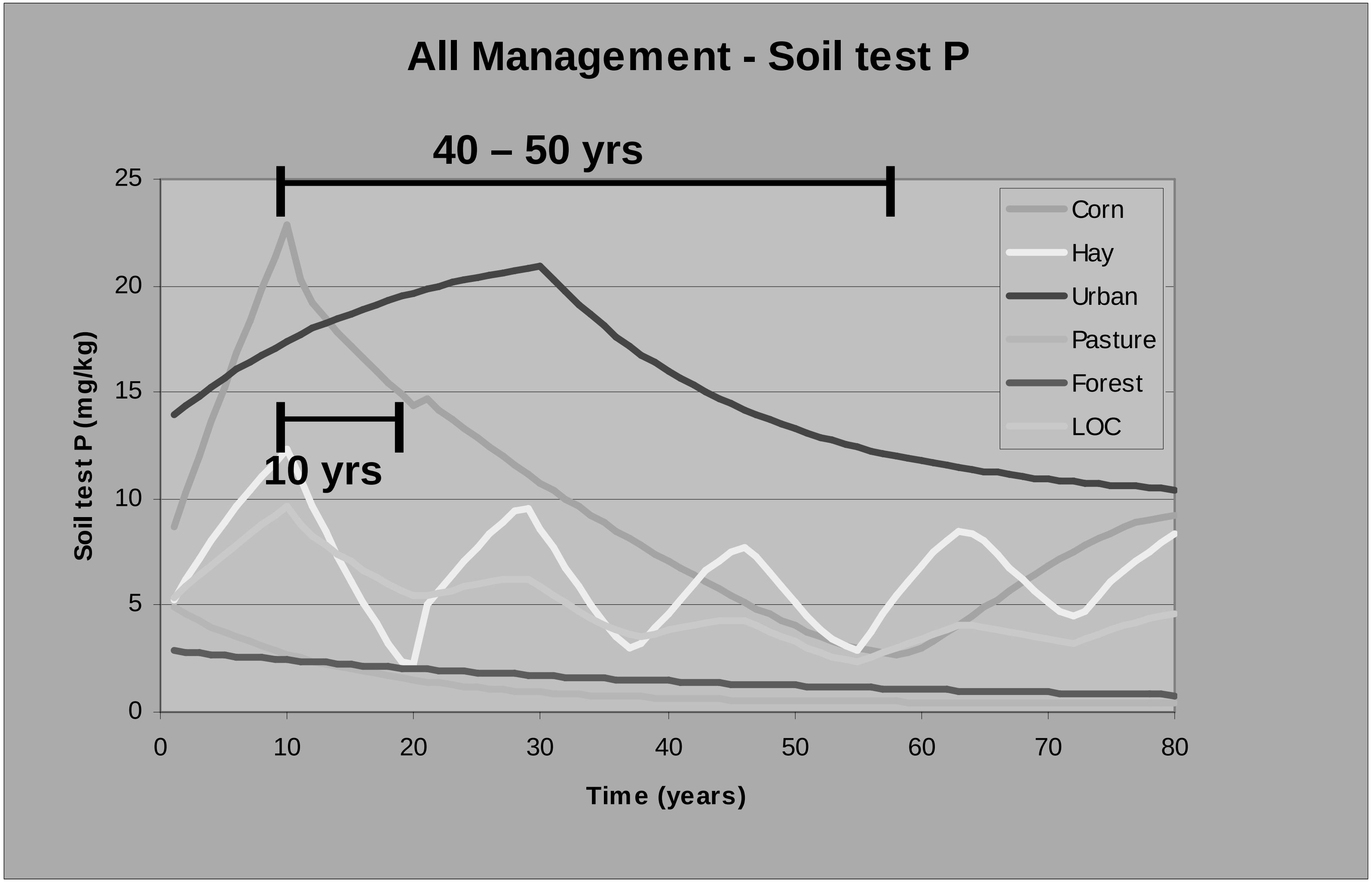
Inland Bays, Delaware

Nitrate from poultry operations delivered by ground water

Ground water time of travel from agricultural land to Bays → 50 to 100 yrs

Magnitude of lag time

Nutrient management, Vermont



Magnitude of lag time

N load to Chesapeake Bay

Nutrient source	Load reductions
Point sources	~immediate
NPS (dissolved)	median time of 10 years
NPS (sediments)	> decades

Estimated that following complete elimination of N applications in the watershed, a 50% reduction in base flow [NO_3] would take ~5 years, with equilibrium reached in about 2040.

Dealing with lag time

Dealing with lag time

Recognize lag time and adjust expectations

Dealing with lag time

Characterize the watershed

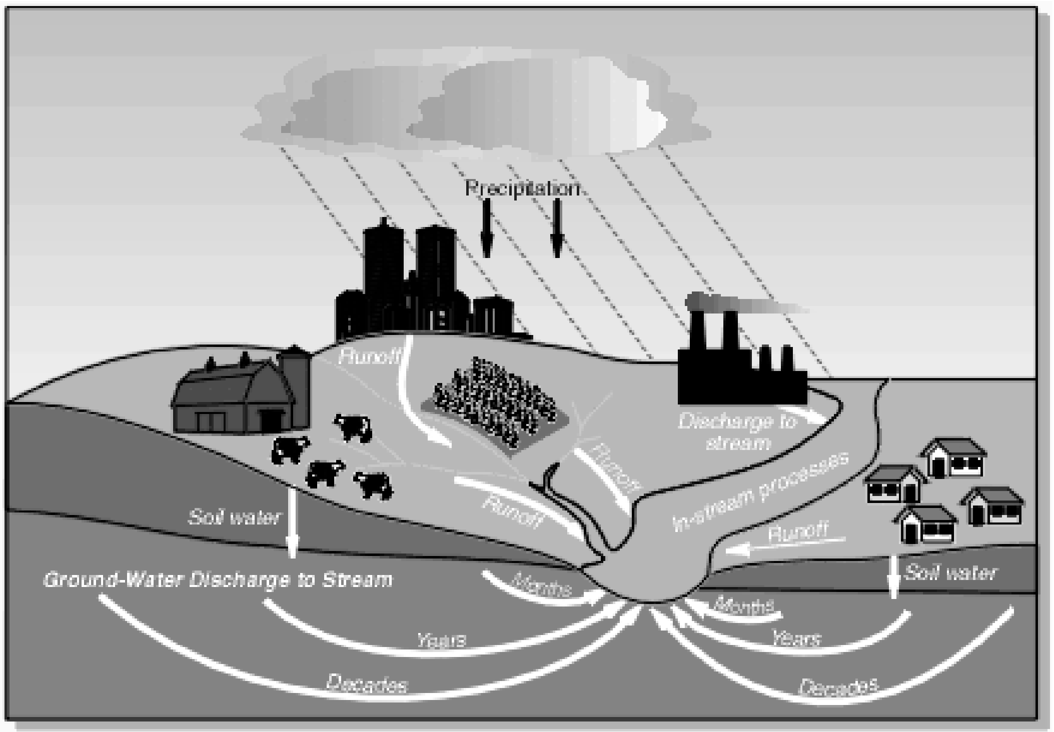


Figure 2. Nutrient movement in the ground-water-flow system.

Dealing with lag time

Consider lag time in selection of BMPs

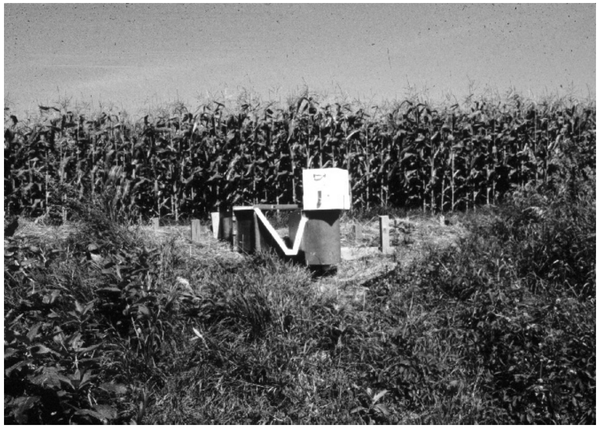
Dealing with lag time

Consider lag time in siting of BMPs

Treat sources likely to exhibit short lag times first to increase the probability of demonstrating WQ improvement as quickly as possible. **BUT →** “Quick-fix” practices with minimum lag time should not automatically replace practices implemented in locations that can ultimately yield permanent reductions

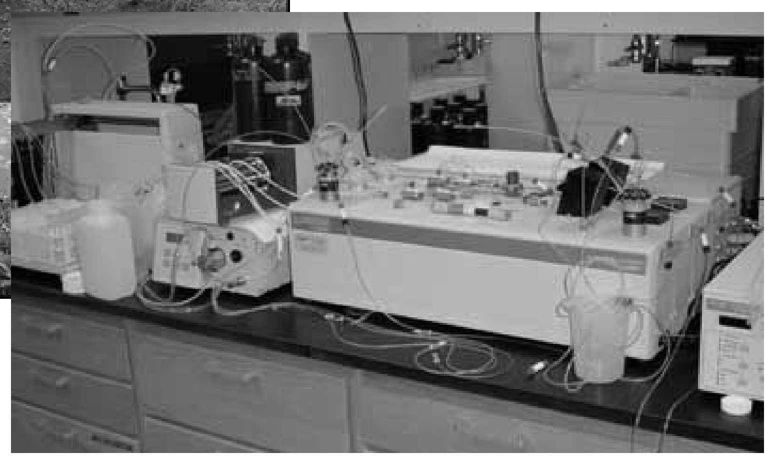
Dealing with lag time

Monitor small watersheds close to sources



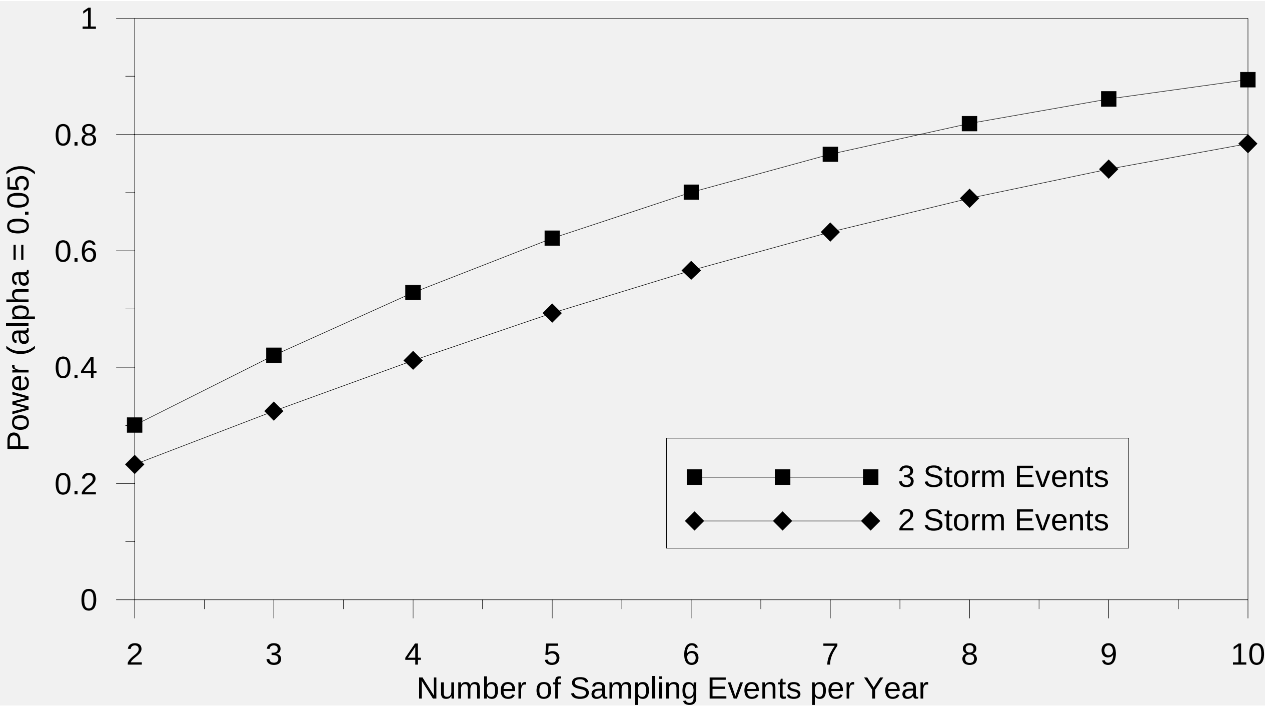
Dealing with lag time

Select indicators carefully



Dealing with lag time

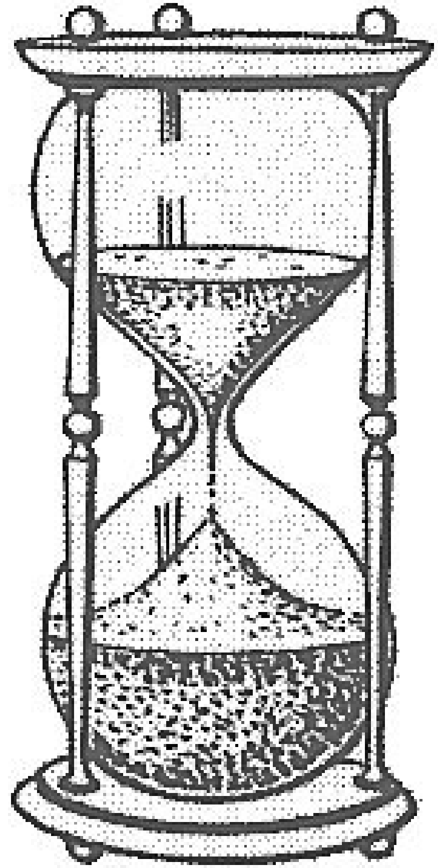
Design monitoring programs to detect change effectively



Dealing with lag time

Use social indicators as intermediate check on progress →

Are things moving in the right direction?



QUESTIONS?